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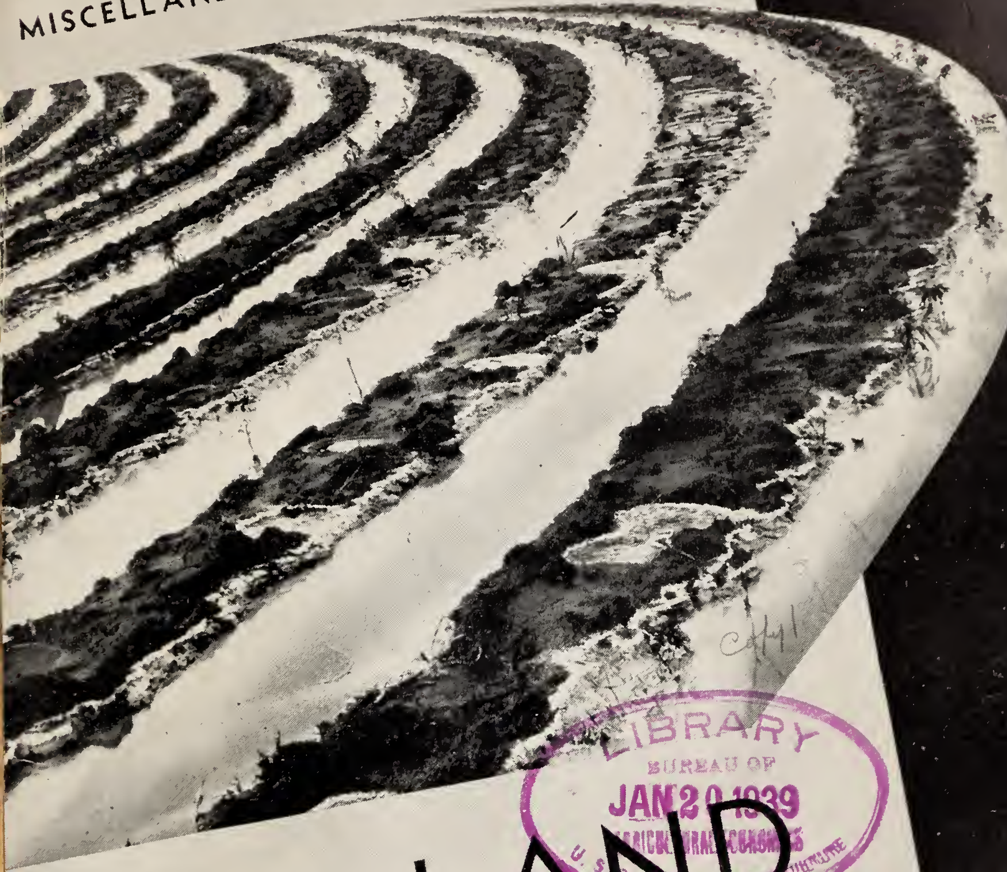

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THE LAND IN FLOOD CONTROL

UNITED STATES DEPARTMENT OF AGRICULTURE

THE LAND IN FLOOD CONTROL

• OFFICE OF LAND USE COORDINATION •

UNITED STATES DEPARTMENT OF AGRICULTURE

MISCELLANEOUS PUBLICATION NUMBER 331

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THE LAND
IN FLOOD CONTROL

IN THINKING of flood control one visualizes dams, levees, reservoirs, and other massive structures. It is natural to do so, for the national efforts at flood control in the past have been highly specialized. As a nation we have relied almost solely upon the engineer, who has exercised rare ingenuity and skill in designing and building structural works to meet the challenges of floodwaters.

In the past several years there have occurred a number of destructive floods on the major waterways and a multitude of minor ones on their tributaries. These have struck widely separated parts of the country, causing unprecedented damage. Especially the floods in the lower Mississippi Valley in 1927, in the Northeast in 1936 and 1938, in the Ohio Valley in 1937, and in southern California in 1938 have awakened a lay interest in flood control. As a result laymen have begun to reexamine critically the whole flood-control program.

Engineers, the layman finds, are coping year by year with an apparently more difficult problem. Streams are repeatedly rising out of their channels and threatening to overtop the strongest and highest levees. Engineers must contend with increasing quantities of silt from misused lands upstream. Stream beds and reservoirs are filling with debris. Estimates of maximum possible flood heights are being revised upward. And although flood records are incomplete and cover only a relatively short period of time, they lead many to suspect that floods have become more violent and more frequent as well as more damaging.

Our reexamination reveals that others besides engineers have a responsibility to meet in regard to flood control. Engineers are deserving of, and must be given, more help from other segments of society than they have had in the past. Consequently, we are beginning to ask of the man who lives in the upstream drainage areas, where the floodwaters collect, to "chip in" and help.

For years the Department of Agriculture and the State agricultural experiment stations have studied the influence of vegetation and land use practices on water flow. The inescapable conclusion of all the researches of the Department is that conservation farming practices and forestry can help materially to retard the flow of water and wastage of soil. It is no longer a question of whether flood-control measures on land will be materially helpful. It has now become a question, rather, of discovering how well we can coordinate the efforts of soils men, agronomists, foresters, farmers, ranchers, lumbermen, and others with the efforts of engineers so that we can get the maximum returns from the total investment in flood control.

There is no longer any doubt that the uses to which we have put our land have been responsible for much of the silt and water which make up a flood. The story is written plainly on the land; and the experiences of other countries, whose histories are longer, can help us to read the story. Contending with tremendous pressures of population on the land, some of them have stripped their hillsides and mountainsides of vegetation and precipitated torrents on the plains, not because they wanted to, of course, but because they could not do otherwise. They were lacking in knowledge, engineering facilities, communications, and governmental power which are necessary to arrest land exploitation. Other countries more fortunately equipped—notably France, Switzerland, and Italy—have been able to minimize flood damages by coordinating land measures for flood control with a structural program on streams.

In the United States, fortunately, local, State, and national legislative bodies recently have provided laws which furnish mechanisms through which flood-control problems may be attacked cooperatively. The United States now has the scientific knowledge, the physical power, the means, and much of the social machinery with which to correct past mistakes in land use, and, above all, it still has time to act.

Congress several times has expressed its conviction that flood-control operations should include not only the improvement of rivers and waterways but also the treatment of lands that shed water. This conviction is embodied in all national flood-control legislation since the passage of the Omnibus Flood Control Act of 1936. This act authorized a coordinated land-and-water program for flood control. It called upon two departments of Government, War and Agriculture, to integrate their efforts. Under the act, responsibility for improving rivers and waterways rests with the War Department. The Department of Agriculture is charged with undertaking works and measures for run-off and water-flow retardation and soil-erosion prevention on the flood-producing watersheds of these rivers.

The upstream flood-control program which the Congress has authorized is essentially part of the national program of promoting wise land use, which includes the application of such conservation farming and forestry practices as retard run-off and arrest soil erosion. Such practices are simply adaptations of nature's conservation and flood-control methods to the conditions of advanced cultivation. The principle of all of them is simple: To make running water "walk" or "creep," to store a far greater part of it in the soil; and to do this by making the soil and its crops provide, as impediments to run-off, millions of natural little dams. By the simple device of plowing and cultivating around the hill, for example, each furrow, each harrow scratch, becomes in effect a small dam or terrace. On steeper slopes somewhat more elaborate methods may be needed, such as forestation, terracing, strip cropping, etc. Other segments of the national land use program may be made to contribute to flood control. Eroded submarginal farm land that is contributing to flood flows may be purchased and retired from cultivation, and misused forested lands may be acquired for flood control and other public purposes.

Thus the flood-control program does not become a new program of the Department of Agriculture in the sense that new types of activities are undertaken. It presents no new technical problems to the Department, and requires no new agency to set up to carry out the purposes of the flood-control acts. Existing bureaus of the Department are already equipped to go ahead with various phases of the program. The flood-control programs require in their upstream phases, however, complete coordination of all land use programs, and reemphasize the interdependence of the Department's many and varied activities.

ROLE OF VEGETATION IN FLOOD CONTROL

Agriculture, grazing, logging, and fire have profoundly altered this continent. The first settlers to come to our shores found the land covered with vegetation. The East and South was a vast forest. The pioneers cut or burned much of this forest to make way for fields and homes. As they pressed westward in response to the call of fresh, new soil, they settled prairies and plains carpeted with grass. Plows turned down the sod. The tide of settlement swept onward to the Far West. Great herds of sheep and cattle were brought to graze the grasses and shrubs on the western lands. As the Nation grew it needed its many millions of acres of land for agriculture, grazing, and logging to produce food and fiber and to supply materials for homes, manufactures, and export; and before the incessant demands of a growing population and expanding industrial activity much of the native vegetation disappeared.

In preagricultural days, when most of the continent lay protected under a dense cover of vegetation, when there were no deep-cut gullies in the soil, when streams flowed clear and rippled over gravelly beds between vegetated banks, it is reasonable to believe floods were fewer and less violent. Depletion of vegetation on the watersheds, the substitution of tilled crops for trees and grass, overgrazing, destructive logging, and fire removed many of the natural checks against rapid run-off from the land. On watersheds no longer wholly protected by grass or forests, rain water collects more quickly and moves more rapidly into tributary streams and major waterways, carrying soil stripped from the slopes. Millions of tons of soil are carried into the major streams each year, choking creeks, shoaling river channels, filling reservoirs, clogging harbors, or moving into the sea. These huge quantities of erosional debris when deposited in places of quieter current, diminish the carrying capacity of many watercourses, large and small, and reduce the storage space in reservoirs.

Vegetation acts in a variety of ways to slow run-off, reduce its volume, and hold the soil. It may be useful to mention briefly the more important of these.

First, vegetation renders the soil capable of absorbing moisture rapidly. The soil is far from being a solid mass. Its natural texture is more nearly like that of a bathroom sponge. A cubic foot of topsoil may contain as much as 60 percent of air. Soils in virgin forests and grasslands are the most porous of all. If you dig into such soils you will find that they have loose, crumby structures. You can almost work them with bare hands. Such soils can absorb water almost as fast as you can apply it. They can absorb 12 or 15 or more inches of rain. The upper 3 inches of forest soils taken from old-growth stands of hardwoods in the Ohio Valley, for example, absorbed 14 times as much water a minute as the more compact adjacent field soils, and the upper inch 50 times as much.

Grass is perhaps the most effective agency that helps in the development of a crumb structure in soil. The most important single factor responsible for the development of good structure is soil organic matter. Grass roots penetrate most soils to considerable depth. When these roots die and decay, as many of them do each year, they impregnate the soil with humus. Recent studies of grass in Canada reveal why grass roots are so important in developing soil structure and infiltration capacity, and in helping to bind soil particles together. A single cultivated grass plant, the National Research Council of Canada reports, may produce 54 miles of roots in 1 year.

Soil in a forest and the litter covering the soil teem with plant and animal life. A ferment of activity goes on, conditioning the soil for absorbing water. Root tips push out and open minute passages. The roots of trees and shrubs go deep, die, decay, and leave channels for water to enter. Fungus organisms appear, flourish, and decay. Insect larvae and rodents burrow and churn. A square yard of forest litter may hide thousands of tiny animals—spiders, springtails, centipedes, and many others. Incessantly active, these plant and animal organisms help to make a forest soil mellow, friable, and absorbent.

Soils used for agriculture also have a high capacity for absorbing water. The theoretical capacity of the upper 36 inches of three representative agricultural soils was found to be 14, 16, and 21 inches of water. The rate of penetration into such soils is not nearly so rapid as in forest and virgin grassland soils. Yet even if only half of this amount of moisture were held on the land and directed into the soil by vegetal and mechanical measures, conservation treatment would make an important contribution to flood control.

Clear water penetrates into the soil easily. Muddy water does not; as it sinks into the soil the fine particles filter out, leaving a thick film which quickly chokes the minute openings, just as muddy water clogs the pores of a cloth sieve while clear water pours through indefinitely. When W. C. Lowdermilk, in testing infiltration rates for the Forest Service, introduced 2 percent by weight of sediment into clear water the rate of percolation fell to 10 percent within 6 hours. This sealing effect was lasting. Subsequent use of clear water did not restore the original rate of percolation. This suggests another important contribution of vegetation to run-off control. Under forest, grass, or other close-growing crop, a layer of litter lies over the surface of the soil. Rain strikes this litter and does not pelt against a bare soil and collect in muddy rivulets, as it does in cultivated fields.

Forest cover retards melting of the snow in the spring. This is an important benefit in regions of heavy snow. Melting of snow under forest cover takes place more slowly, usually permitting ample time for the snow water to soak into the ground. Moreover, the ground in the forest is less likely to be frozen than land in the open. This and the prolongation of the melting period result in a higher proportion of snow water being absorbed. On the other hand, the snow retarded from melting by the forest cover may, by chance, be carried off by a heavy early spring rain and thereby contribute to flood flows.

In all plot experiments soil and water losses are greatest when the land is bare of vegetation; next in magnitude are the losses from lands devoted to clean-tilled crops, such as cotton, corn, tobacco, potatoes; and least in magnitude are losses from ground covered with forest, grass, clover, alfalfa, and shrubs. Summing up the average comparative losses from experimental plots in 13 widely separated agricultural regions, the Soil Conservation Service found the loss of water from clean-tilled fields was 7 times greater than the loss from fields protected by close-growing crops, such as grass, legumes, woods. The loss of soil was 174 times as much as from protected areas. These plots are located on agricultural soils representative of or closely related to the principal types of farm land within a predominantly agricultural area of approximately 250 million acres.

The foregoing paragraphs tell only briefly of some of the results of research studies of the influence of vegetation and land use on run-off and erosion. Although most studies are on small plots, and only a few involve larger watersheds, the largest embracing 17,000 acres, the data whether from large or small areas, support certain conclusions. Restoring and maintaining a dense watershed cover on uncultivated lands and applying conservation practices to agricultural and forest lands will (1) reduce the quantity and rate of run-off from drainage areas during times of flood crises, (2) increase ground-water supplies, which will tend to regularize stream flow, and (3) reduce erosion and the rate of deposition of debris in flood-control structures, such as reservoirs, detention basins, and waterways, and arrest shoaling of stream channels.

EXTENT OF VEGETAL DEPLETION

In the United States there are approximately 1,903 million acres of land. Some 413 million acres, formerly grassland and forest, are tilled for agriculture. Approximately 630 million acres are classed as forest land. Pasture and range, not including grazed forests and woodland areas, total 696 million acres. The balance, 164 million acres, are made up of waste land, roads, urban developments, and farmsteads.

A high proportion of the 413 million acres of cropland is managed with little provision for controlling run-off adequately, especially in regions such as the Corn Belt and the Cotton Belt, where row crops predominate. So rapid is run-off from many sloping cultivated fields that practically all of the topsoil has been washed from 50 million acres of land, according to a Soil Conservation Service survey. This land is rapidly approaching total destruction. It is no longer farmed. Approximately 100 million acres still in cultivation have lost all or a greater part of the topsoil. It is estimated that half of the Nation's better cropland has been affected to varying degrees by erosion caused by uncontrolled run-off. Millions of gullies have appeared. When it rains, water accumulates in these gullies and is directed immediately into stream tributaries.

Many forest lands are no longer well protected. The Forest Service classifies 83 million acres of cut-over and burned-over forest land either as poor or as not restocking. Approximately 850 thousand acres are cut over destructively or devastated each year. Fire sweeps over some 36 million acres of forest land annually, destroying all or a part of the cover and the vegetal litter.

In a recent survey of western range lands over 80 percent of the entire range area, some 728 million acres, was found to exhibit more or less serious accelerated erosion, evidence of more rapid run-off now than in the past. Overgrazing and drought have wrought pronounced transformations in the range cover. Over extensive areas the better forage grasses have been displaced by inferior nonforage plants. The encroaching plants are inferior soil-holding species, and the total cover is usually much less dense. The survey, which is reported on the basis of grazing capacities, revealed that the cover is depleted 25 to 50 percent on 34 percent of the range; 51 to 75 percent on 37 percent of the range; and 76 to 100 percent on 16 percent of the range. Depletion amounted to less than 25 percent on only 13 percent of the western range.

It is neither suggested nor implied here that lands should be returned to a state of nature merely for the sake of flood and erosion control. Such an idea, generally speaking, is absurd. There are some areas which should be removed from cultivation and put to other uses for the sake of the people living on the land as well as for the sake of the land itself and the people living downstream; but these are special problems requiring special solutions. Over most of our millions of acres of agricultural, forest, and range lands the problem is one of management—management so that investments in labor and capital will be maintained intact, and wastage by run-off, erosion, fire, and flood will be held to a minimum.

After all, land management for conservation is a means to an end; it is not an end in itself. We conserve natural resources and plan their more effective use for aid in flood and erosion control and drought alleviation in order to promote human welfare. We do it so that we may produce continuously the food, fiber, and timber that we require. Watershed treatment cannot succeed if it envisages only the conservation of soil and water. Each program on each watershed must also take into account the people living on the land and their well-being. Whether land is cropped, forested, or pastured, whether it is operated by owners or tenants, it must, if privately owned, yield a fair return as well as protect existing values downstream.

In order to arrest run-off and control erosion it is often necessary to make extensive changes in farming and tillage practices and to supplement vegetative measures with structural works. On most farms adjustments and structures may repay the farmer for his expense and trouble; but on others preventive measures may be too costly and too great a drain upon the resources of the farmer. There are, also, many instances where the public benefits of water control greatly exceed the benefits to the man who uses the land. It is under conditions such as these that public funds may be fairly used to meet the cost of putting erosion and flood-control measures into effect on privately owned land. The public may reckon its gains in terms of protection to life and homes, reservoirs and property, and preservation of productive lands which otherwise might be lost through soil erosion, stream-bank cutting, or be buried under sterile deposits of sand and gravel—lands which must be preserved for the support of posterity.

LIMITATIONS OF VEGETAL CONTROLS

It cannot be claimed that vegetation offers a complete solution to the flood-control problem. Indeed, for 70 years competent critics, here and in Europe, have questioned whether vegetation offers any appreciable control over water flow. Even yet it is not possible to estimate precisely its effect under flood-producing conditions. Studies have not been made over a period of years on complete watersheds of considerable size; and consequently precise predictions of the effect of watershed treatment on flood crests cannot be made. But research has progressed far enough to command that treatment be given to watershed lands to protect structures downstream and communities and lands upstream.

There is grave danger that too much may be expected from watershed-protective measures. In the past extravagant claims made by proponents of vegetal controls provoked equally extravagant rebuttals from the proponents of the "structures only" school of thought. In Europe the controversy reached its height some years ago and cooled, and the several nations have accepted, as governmental policy, that land management—including forestation, conservation farming practices, and minor upstream structures—must be an essential part of a complete water-control program, if damaging floods and torrents are to be avoided. This is unlike the past policy in this country. Until recently, practically the entire national as well as local effort toward flood control has been limited to such devices as levees, floodwalls, floodways, and to equalizing reservoirs in the larger streams, for the most part in downstream situations.

Works of this nature are absolutely necessary and their importance should not be minimized, but they afford no protection to inhabitants or property on smaller streams and tributaries, and they accomplish nothing toward the preservation of the soil.

It should be clearly understood that watershed-protective measures can never supplant control works along the major streams so long as flood plains are occupied, sometimes in defiance to the normal nature of the streams. For floods occur even under primeval conditions. Garciliaso de la Vega, a member of De Soto's exploratory expedition, recorded a flood in the lower Mississippi Valley in 1543, over two centuries before the valley was occupied by white men. La Salle also found the Mississippi in flood. At one time the Gulf of Mexico reached deeply into what is now the Mississippi Valley. The vast alluvial plain of the river, geologists tell us, was made of soil carried by floodwaters, just as land is being made today in the Gulf of Mexico beyond New Orleans. The history of this mighty stream is written in the great mass of deposits that it laid down through the centuries. The geological characteristics of this material tell a story of the changes wrought by white occupation of the upper watersheds. A soils man, H. H. Bennett, Chief of the Soil Conservation Service, interprets the story:

> Overlying the old alluvial soils of numerous streams throughout the United States—the material laid down by timeless floods—is a different kind of alluvium. It consists of sediments spread out by floodwaters since the beginning of our agriculture. Such deposits reveal unmistakable proof that, generally, they were spread over the flood plains by waters much more violent than those which laid down the vastly older material beneath.
>
> That the deposits of the preagricultural state developed under moderate overflows is shown by their prevailing finer texture and more uniform composition. The line of separation between the two types of alluvium is so sharp that it is usually possible to photograph it without any difficulty. In many instances, the depth of the new material is greater than the entire depth of the older underlying deposit, and generally, it is not

only coarser in texture, but far more diverse with respect to textural composition and color characteristics through the profile.

The Bureau of Chemistry and Soils is today mapping a number of new alluvial soils entirely different in character from those of pioneer days, now entirely buried. We have the history of these soils. We know definitely that they have formed since the agricultural occupation of the country, and there is ample proof that these later deposits were laid down by more violently flowing waters than those of former times.

Since there always have been spring rises and floods we may expect them to continue. It is not difficult to imagine a set of conditions under which floods would occur from storms over well-vegetated land. In 1762 and 1763, when 98 percent of its watershed was forest-covered, floods swept down the Ohio River. We do not know what weather conditions accompanied these floods. The soil under the forests may have been frozen; deep snows may have fallen; quick-rising temperatures and heavy, prolonged rains may have melted the snow—under such conditions excessive run-off is certain to occur. There is every reason to believe, however, that now, after almost two centuries of white occupation, a flood under similar weather conditions would far exceed the flows of 1762 and 1763.

The flood in the Ohio Valley in 1937 exceeded all previous stages of record between Point Pleasant, W. Va., and Cairo, Ill., at some points by as much as 10 feet. It equalled previous estimates of the maximum flood possible. From the standpoint of property loss the 1937 Ohio Valley flood was by far the most disastrous ever experienced in the United States. It followed excessive rains over the entire Ohio River basin, which began as early as January 6 and continued until January 25. At the center of greatest precipitation, near Dover, Tenn., the total rainfall recorded during that period amounted to about 23 inches, and it was correspondingly heavy at other points. The storm centered in the most critical position, along the axis of the river basin. Possibly no amount of vegetation nor the most intensive land use treatments could cope with such an enormous amount of rainfall in such a short period—half a year's fall within a few days. Such a flood serves to emphasize that watershed treatment for flood control can only supplement the use of structures and can never supplant them.

Those who have weighed the results of data believe that flood-control work on watersheds will probably prove more effective in the control of smaller rivers than of trunk streams, and probably of more value in controlling minor floods than major catastrophic flows. The smaller floods, even those of the smallest brooks, do their proportionate share of damage, and make up in numbers what they lack in magnitude and as spectacles of destruction. Destruction of crops and valley bottom lands, the washing out of roads and bridges, the damage to valley towns and homesteads, and other consequences of these smaller floods, are a source of great loss to the people and communities affected. In the aggregate and over the years such losses may equal or exceed the destruction incurred at the time of the major floods.

EROSION THREATENS STRUCTURES

In some regions of the United States silting of reservoirs and stream channels is taking place so rapidly as to threaten the destruction of downstream engineering works within a few generations. Silt is filling reservoirs and raising stream beds so that levees must be raised higher.

The level of the whole middle Rio Grande Valley of central New Mexico, and in particular the stream channel and floodway between levees, is rising because of sedimentation resulting from soil erosion in the drainage basin. The floodway between levees just below the mouth of the Rio Puerco was built up 4 to 5 feet during the 9 years from 1927 to 1936. Since 1891 the channel width of the Anacostia River in the District of Columbia has been reduced from approximately 70 yards to about 25 yards. The average rise in the river bed has been about 3 feet. Small freight boats plied between Bladensburg, on the Anacostia, and other ports in the Chesapeake Bay section 100 years ago, but Bladensburg is now inaccessible to even the smallest boats at normal river stage.

Navigation and commerce on the Galena River in Illinois virtually ceased after 1863 as a result of silting of the stream channel. In the 1830's small steamers could run 1 or 2 miles above Galena and large steamboats came up as far as this city except during very low stages of water.

The Inland Waterways Commission reported in 1908:

> Pearl River (Mississippi) has completely changed its character in the last half century; from a slow, clear stream it has become a swift, muddy one, and from a good channel with a depth of five or six feet it is now shallow and much obstructed with drifts and logs. This rapid filling is due to the washing of the sandy uplands that have been opened up along the stream, with consequent choking of the river channel.

As long ago as 1896 Erasmus Haworth, then State geologist of Kansas, wrote regarding the Arkansas River:

> Within the last fifteen years a very noticeable filling in of the river channel has occurred. The various bridges which are built across the river at different places when constructed from eight to twelve years ago were usually built high enough so that a man on horseback could easily

ride under them while sitting erect. At every bridge along the river the sands have accumulated until the most of them are not more than from 3 to 6 feet above the top of the sands.

These are but isolated instances. Published reports refer to similar filling of the channels of the Apalachicola, the Tennessee, the Red River of the North, Virginia tidal streams, the lower Brazos and lower Colorado in Texas, and the lower Colorado of the West.

There are even more examples of reservoir silting. Extreme cases have occurred in the southern Piedmont. Thirteen major reservoirs there, with dams averaging 30 feet in height, have completely filled with eroded material. Their average useful life was 29.4 years.

A municipal reservoir built near Spartanburg, S. C., at a cost of $470,000, lost 17 percent of its original storage capacity in 8 years. Another near Waco, Tex., costing $2,000,000, filled one-fifth with silt in less than 6 years after construction. Lake Olathe at Olathe, Kans., costing $42,000, filled 10 percent in 5 years. Elephant Butte Reservoir near Hot Springs, N. Mex., costing $5,000,000, lost 14 percent of its capacity in 20 years; and Gibraltar Reservoir at Santa Barbara, Calif., costing $800,000, was 30 percent silt-filled after 16 years.

The flood of March 1938 in southern California caused terrific damages to a series of reservoirs built for flood control by the Los Angeles County Flood Control District. Storage losses generally ranged from 10 to 60 percent of original capacity as a result of erosional debris accumulations from this one storm. Such losses virtually destroy the flood-control value of such reservoirs. The actual loss may have reached one-fourth of the original investment of over $21,000,000 (including some reservoirs serving for water supply as well as flood control).

Many other major reservoirs are losing storage capacity as a result of silting. Silting is a hazard of first magnitude in Lake Mead, the lake created by the magnificent new Boulder Dam, in San Carlos Reservoir on the Gila River and in Roosevelt Reservoir on the Salt River in Arizona, as well as in many reservoirs now under construction in western tributaries of the Mississippi, and on western Gulf streams.

Control of erosion in the drainage basins is the only economical and practicable method of dealing with the silting problem. Other methods have been tried, but have been found generally ineffective. Attempts have been made to vent silt from reservoirs through outlet gates and conduits. But the amount of silt thus voided has generally been relatively small. Even if silt could be discharged this way in large quantities, it would have to be dealt with again lower down.

On the other hand, efforts to prevent silt from getting into reservoirs by means of structures and vegetation screens in headwater and valley areas tend to build up alluvial deposits there. Such measures can be applied only when the lands to be used for such silt deposits are of small value. Reduction of silting through the control of erosion on the land conserves soil and water in the watersheds and reduces the rate of sedimentation permanently. It causes no accumulation of sediment either above or below the reservoirs. However, above many reservoirs there is enough silt now in the channel of the stream to constitute a threat even if erosion is arrested immediately on lands above.

The economic importance of reservoir silting can hardly be overstressed. There are more than 10,000 dams and reservoirs in the United States, constructed at a cost of at least $2,000,000,000. This figure does not include the many appurtenant developments depending solely upon them. In many instances these reservoirs are the keystone of vitapower, irrigation, navigation, water-supply, and flood-control developments. Silting impairs these values materially. The damage cannot be measured simply by the cost of the original storage facilities; for additional storage cannot be developed indefinitely at the same cost. When the present sites have eventually been destroyed, the social and economic consequences may be terrific. For many reservoirs there are no substitute sites. Reservoirs usually are constructed at the best sites first. After silting has ruined them it is more costly to provide substitute reservoirs even when it is possible to do so. Eventually, new storage cannot be provided at all. Conservation work on the drainage basins to prevent erosion and silting has the great advantage of maintaining economic values from the beginning.

PROCEDURES UNDER FLOOD-CONTROL ACTS

The flood-control operations of the Department under the terms of the Flood Control Act of 1936, as amended, are restricted to those watersheds that Congress specifically authorizes work upon. As a first step, Congress directed the Department to make preliminary examinations and surveys of designated watersheds comprising the major drainage basins of the United States. The purpose of these investigations is to determine the run-off and soil-stabilization measures necessary for the control of flood-source tributaries.

The preliminary examinations are carried only far enough to determine whether the erosion and flood-control problem is sufficiently serious, apart from purely land use and agricultural considerations, to warrant public assumption of responsibility for control, to determine whether watershed treatment would make an effective contribution to flood control, and to determine whether the benefits from control would likely exceed costs. At this stage it is ascertained whether responsible local and other agencies would be willing to cooperate. Where the preliminary examinations recommend further studies, special surveys will be made to determine the broad outlines of the control program, its costs, and its benefits. After these plans are approved by the Secretary of Agriculture they are submitted to the President, who designates the order of urgency of the projects and correlates the program with that of the Army engineers.

The Congress has appropriated a limited amount of money for a watershed flood-control program. It is a small part of the amount that would be needed to put into effect all of the beneficial measures on all flood-producing watersheds in the United States. The best use of the available funds requires that they be expended where the problem is most serious and where the chances for effecting relief is greatest. Careful study must be given to the social and economic effects of floods in each area on the people directly affected, and on the whole Nation, and to the extent of relief that would be afforded by a control program. A social and economic evaluation of flood-control programs on the several watersheds is needed to guide the expenditure of public funds in a sound manner.

WATERSHED SURVEYS

Surveys are now being made of a number of watersheds. Each survey must develop exact information as to social, economic, physical, and climatic factors. Take, for example, the data that must be gathered about the soil. The physical nature of the various soil types must be ascertained, their texture, depth, infiltration capacity, and structure must be determined; and their erodibility, productiveness, and adaptabilities must be studied.

In the survey great importance is attached to a description of present land uses and topography. This description gives the approximate area in the different major uses, both natural and cultivated, a break-down of the cropland into soil-protecting and soil-depleting crops, degrees of slope, and an historical account of trends in the land use and ownership patterns.

Equally pertinent will be information gathered by the surveys as to the size of farms, their management, their current earnings, and their capital value. Also, the surveys deal with wild land in forest, brush, and range; with the meteorology of the watersheds; with the specific causes of floods; with the physical conditions of stream channels; with the effect of existing stream improvements; and with the character of the drainageways and the size and shape of the watershed.

Flood-damage problems demand close analysis. Typical forms of damage caused by floods include damage to crops and to agricultural and forest lands; damage to municipal and industrial property; damage to bridges, railways, and highways; and damage to livestock and wildlife. Where possible the surveys indicate the money values involved.

The surveys will reveal the extent, location, density, composition, and age class of the forest cover, its fire history, the condition of the forest floor, grazing usage, and other factors affecting the efficiency of the forests on water-flow retardation and erosion prevention.

Investigations are made into the physical and economic damage attributable directly to soil erosion. Estimates indicate the quantity of soil removed through sheet, gully, and stream-bank erosion. Economic estimates measure the damage in decreased production, decreased farm income, and decreased land values. The surveys record damage from the washing of eroded materials onto other land, from the shoaling of streams and the waterlogging of bottom lands, and from the sedimentation of channels, irrigation ditches, lakes, and reservoirs. They include the costs of dredging, of repairing drainage facilities, of restoring irrigation works, and of protecting structures for impounding water for domestic water supply, the production of power, and flood control. Damage to navigation and transportation facilities is reckoned.

The surveys may be expected to reveal those parts of the watershed which, because of their present condition and use, contribute run-off most rapidly and the most silt. The boundaries of these critical areas are delineated, and detailed planning and operations will be restricted generally to these flood sources. Only rarely will it be necessary to treat the whole of a large watershed with an equal degree of intensity. Treatment will usually be confined to the watersheds of the troublesome tributaries.

NATURE OF WATERSHED MEASURES

The techniques employed on land for flood control are, in most respects, those employed for the control of soil and stream-bank erosion. Rapid run-off, the cause of floods, is also the primary cause of soil erosion. With respect to operations on the land, the technical approach to the flood-control problem therefore will be very similar to the technical approach to the problem of soil conservation.

It may be desirable here to describe the nature of flood-control measures on land. They may be divided into four categories: Measures for (1) agricultural lands, (2) forest lands, (3) range lands, and (4) in streams.

ON AGRICULTURAL LANDS

For work on agricultural lands the Department has the benefit of the experience of the Soil Conservation Service in dealing with the problems of soil erosion and water control in demonstration watersheds located in each of the many agricultural regions. There are 175 of these demonstration watersheds each involving 25,000 to 150,000 acres of agricultural lands. Besides this, data from soil and moisture conservation experiment stations are at the Department's disposal. The techniques that have proved locally effective will be applied to the flood-producing areas within the watersheds selected for flood-control operations.

Prominent among these measures are contour farming, terracing, strip cropping, crop rotation, and pasture furrowing. All of these measures are designed to hold back water flow and thus permit more complete infiltration of moisture into the soil. Under a system of contour farming all rows and all plowing and tillage operations follow a horizontal path. Each furrow, each harrow scratch, each row of plants under contour tillage becomes in effect a small dam or terrace, rather than a channel to carry water off the field as quickly as possible as is the case when tillage is up and down hill.

The practice of strip cropping takes advantage of the water-retarding effects of close-growing vegetation. Under this system of crop arrangement, row crops are planted in bands sandwiched between bands of close-growing crops such as alfalfa, sweetclover, and Sudan grass. Run-off from land in row crops, even under contour cultivation, is more rapid than run-off from land in close-growing crops. Water in leaving the band of row crops passes through a strip of close-growing crop and is retarded, its soil load is removed, and more moisture enters the soil. By rotating crops in the strips, and including green-manure crops and legumes in the rotation, the fertility and organic content of the soil may be maintained or improved. This is helpful in maintaining infiltration rates.

Terraces intercept water as it flows down a slope, and hold it in a channel of earth where it either soaks into the ground or moves slowly to the side of the field. Here it is emptied into woods, on grassland, or into a patch of meadow, or in some instances it is directed into a drainage ditch. Terraces thus permit more ready infiltration of water into the soil and to a marked degree prevent quick concentration of water in natural channels.

In some areas terraces are constructed with closed ends so that all of the rainfall is held within the field.

Pasture furrowing is an adaptation of the contour-farming principle to pasture lands. Grass in pastures is often sparse, and run-off from such land may be rapid. A system of shallow furrows, run horizontally at intervals over the pasture, holds practically all of the normal rainfall within the pasture field.

Run-off from steeper slopes is usually more rapid and more erosive than run-off from slopes less steep. Many slopes now cultivated are too steep for crops that are planted in rows, and the usual water- and soil-control measures for cultivated land—contour tillage, strip cropping in rotation, and terracing—do not give sufficient control over water flow and erosion. Such slopes should be planted to close-growing perennial crops or to trees.

In many of the older farming sections and in areas where the soil is especially erodible or the rains torrential, much and often all of the absorbent topsoil has been removed from the land, and the land has become gullied. Such land quickly loses its rain water. The gullies in effect are extensions to the regular network of stream drainages. The soil on such land can be held at home only by planting it to trees, shrubs, and vines. Often it is necessary to construct in the gullies inexpensive soil-saving dams made of native materials, to aid the plants in getting started.

Throughout eastern United States, especially in hardwood areas, the practice of grazing livestock in the farm woods compacts the soil, eliminates litter, and eventually halts regeneration of the forest species. Under continued grazing the forest nature of the farm woods is lost, infiltration decreases, and run-off increases. Control of grazing preserves the productivity of the farm woods and contributes to flood control.

ON FOREST LANDS

The Forest Service in managing 175 million acres of national-forest lands, has developed many water-control techniques. These measures have been thoroughly tested, especially in the years since the Civilian Conservation Corps has been available for conservation work in forests.

The purpose of watershed measures in established forests is to strengthen the vegetation that is present. A forest may appear from across the valley to be fully stocked with trees, but on close inspection the stand often is found to be poor. The soil may be unduly compact and lacking adequate litter protection. There may be areas ravaged by fire or logging.

Undesirable species may predominate. There may be within the forest large outcrops of rock, openings where the soil is thin, overgrazed patches, and scattered abandoned farms. Such situations call for a repair job. The obvious action is to replace trees destroyed by fire or lumbering by means of planting or seeding. Much of the protective work on forested watersheds points toward immediate replacement of damaged and lost vegetation and measures to encourage immediate natural reproduction of trees and shrubs.

Forestry work for flood control involves the planting of grasses and shrubs as well as trees. In many cut-over and burned-over areas tree plantings cannot be expected to succeed, owing to the loss of soil that occurred following the loss of vegetal cover. In these areas grasses and shrubs will be planted. Trees may then come in naturally when conditions are ready to support them.

Sowing of a cover crop as an emergency measure deserves special mention. In areas where the cover of vegetation is totally destroyed by fire and a heavy rain would threaten a local disaster, a cover crop may be planted for immediate protection. Some 150 plants have been tested by the Forest Service, and of them all black mustard gave the best protection most quickly. It is now the policy to sow mustard seed immediately after a devastating fire in national forests in southern California. The seed is sown from airplanes or by hand. Mustard seed germinates quickly, the plants grow rapidly, the primary leaves are of the type that protect the soil, and the crop makes a heavy litter. The cover crop holds the soil until natural vegetation can take over. The mustard is completely displaced by natural vegetation in 2 or 3 years.

In denuded areas it may be necessary to help nature with mechanical supports. Contour terraces have proved successful in the West on critical flood-producing areas in forest lands, as aids to vegetation. The purpose of the forest terrace is to hold back surface flow. It is a detention rather than a drainage structure, and is built like a small dike. No effort is made to maintain forest terraces. The terrace trenches fill with leaves and other litter, but this accumulation serves to enrich the soil and render it more porous. The trenching work of the West may be modified and introduced in the East. Hillsides pockmarked with terracelike trenches deliver little floodwater even though the stand of vegetation and soil condition are poor.

Not all types of forests are equally effective in controlling run-off. The type of vegetation present in a forest has a marked influence on the soil. Some species of trees condition the soil to absorb water better than others.

For example, soil in forests that contain mixed species such as the maples, ash, and yellow poplar, is usually more absorbent than soil in forests of such trees as oak. The soft leaves of the first group of tree species decompose more rapidly, and by fostering the organisms of decay bring about quicker disintegration of all organic material on the forest floor. This helps to maintain soil life. In practicing selective cutting and thinning, the forester can favor soil-improving species and thus aid in preventing formation of a compact soil.

The State and Federal Governments through cooperative arrangements with local agencies have developed an efficient forest-fire protective system. Aside from conserving the forest resources, this system of fire prevention and control helps to prevent floods, by maintaining the forest cover intact. It may be desirable, purely in the interest of flood control, to strengthen this service in critical areas—on a watershed, for example, which lies immediately above valuable improvements and urban developments downstream. Construction of fire lanes, from which fires may be fought, and clearing of firebreaks, will further safeguard such areas from devastating fires.

ON RANGE LANDS

Overgrazing is the primary cause of accelerated erosion and run-off on range lands. Stocking the range too heavily has injured the grasslands, some of them irreparably. The native perennial grasses and browse plants that maintained the soil in good physical condition have almost disappeared from vast areas of the western range, and much of the topsoil has departed with the grass. Recovery has been arrested by prolonged periods of drought and continued overgrazing. Overgrazed range lands are the source of the vast quantities of silt that fill the western reservoirs, the source of flash floods, but over the years the source of little of the water that flows in the irrigation canals. The steadily flowing streams of the forested mountains, where rainfall and snowfall are greater and more reliable, furnish most of the water.

The grasses and browse plants may be brought back to the depleted range lands by improving range-management practices, but the program must necessarily, in the arid range country, cover a long period. Where the balance between climate, vegetation, and soil is delicate, and a great deal of topsoil has been lost because of past abuses, nature cannot be hurried. A pick-up in the rate of recovery would undoubtedly follow exclusion of stock, but the general dependence of local people on the range makes exclusion unfeasible except on highly critical areas.

The first and most important of the steps which must be undertaken is that of adjusting livestock numbers to the grazing capacity of the range. Without this fundamental achievement, other efforts to improve the cover of vegetation on the range cannot be of lasting benefit. Measures that provide additional relief are those which aid in the distribution of livestock over the range lands, and which provide for the proper seasonal use of the forage. Such management practices as rotational and seasonal grazing, salting stock away from watering places, and the provision of an adequate number of watering places evenly distributed over the range, fall within this category. Control of run-off and soil erosion may be achieved by special measures on specially critical areas, but the range country is too vast to rely generally on the relatively more expensive practices. When flood control is considered apart from erosion control, such measures as contour furrowing, range terracing, building of water spreaders and check dams across gullies and arroyos, building of detention and retention structures, and the revegetation of sorely depleted lands by seeding of forage grasses must be confined to critical flood-source areas.

IN TRIBUTARY STREAMS

The Department of Agriculture, in order to complete its watershed treatment of critical areas, must supplement its land use adjustment measures with upstream engineering devices for the control of flood flows in headwater streams. The Department, therefore, will work from the headwaters toward the War Department's structures downstream.

Upper watershed structures are of the simple, relatively less expensive types, ranging from check dams in gullies, arroyos, and other small drainages to ponding basins for floodwaters farther downstream. Structural work on upper watersheds is largely for the purpose of breaking the destructive force of the flow. In some instances on mountain slopes a series of stream barriers to serve as desilting basins and to step the water down gradually may be necessary. Farther downstream, on the flood plains, protective works will be installed to stabilize stream banks, stream beds, and alluvial deposits. Vegetation rather than structural materials may be employed in much of this stabilization work.

TEAMWORK IS ESSENTIAL

The United States is definitely and surely moving toward national, State, and local cooperation in various land problems, and watershed treatment for flood control will have a prominent place among these cooperative endeavors. Cooperation in an undertaking of this type is essential, since much of the work will be done on privately owned lands. To accomplish flood control is not simply a matter of money. Limitless funds would not produce results without the willing, informed cooperation of those who use the land. Land use practices and conservation measures, unlike structures of steel and concrete, will not function without the day-to-day attention and interest of the person who is making his living from the land.

The task of securing cooperation is largely a State and local function. It requires suitable State legislation, such as a State soil conservation districts law, which will guarantee that the watershed measures completed with the Department's assistance will be suitably maintained.

SOIL CONSERVATION DISTRICTS LAWS

The Soil Conservation Act of 1935 authorized the Secretary of Agriculture, as a condition to the extension of benefits under the act to lands in any State, to require the enactment of State laws providing suitably for the prevention of soil erosion. In conformity to this provision, the Department of Agriculture drafted a standard State soil conservation districts law, with the hope that it would serve as a basis for the enactment of approximately uniform State conservation legislation. By July of 1938, some 26 States had enacted legislation modeled after this standard law.

In language closely similar to that used in the Soil Conservation Act, Congress authorized the Secretary, in the 1937 amendments to the Flood Control Act of 1936, to require the enactment of laws providing suitable safeguards for local cooperation in the flood-control program as a condition to extending benefits to any State in prosecuting measures for run-off and water-flow retardation and soil erosion prevention. The work of the soil conservation districts in erosion control is very closely and intimately related to the work which needs to be done on watersheds in aid of flood control, through run-off and water-flow retardation and soil erosion prevention. In fact, in many areas the measures which need to be taken for effective erosion control are the identical measures needed to achieve "run-off and water-flow retardation and soil erosion prevention" in aid of flood control. It follows that, just as it has been found necessary to provide for the organization of soil conservation districts which can supplement and extend erosion-control operations, it is equally necessary for soil conservation districts to supplement and extend the work which the Department is authorized to do on watersheds in aid of flood control.

In a memorandum to the Chief of the Soil Conservation Service, dated December 10, 1937, the Secretary of Agriculture wrote:

I hope that other agencies of the Department also will begin to move so that they may be able to work through the soil conservation districts. It seems to me that these districts in the future may be found to present an opportunity to the Department to unify a number of the different action programs which the Department is now authorized to carry on. Through the local soil conservation districts the Department should be able to assist farmers in formulating and executing comprehensive plans for bringing about wise land use. I think it is important, therefore, that the districts should not come to be looked upon as having significance only for the program of the Soil Conservation Service, but that they should be seen as local governmental units, organized democratically, functioning over properly bounded areas, and possessing the necessary governmental power to enable them to carry on well-rounded agricultural programs. The districts need the help of most of the agencies of the Department and, in turn, they can help the Department as a whole to carry out more effectively the various programs it is administering.

On October 29, 1938, the Secretary of Agriculture announced that the following policies will govern flood-control work by the Department on lands which are predominantly in private ownership or in non-Federal public ownership:

1. Immediate preference will be given in carrying on operations on watersheds in aid of flood control, to areas within States that have adopted legislation along the lines of the standard State soil conservation districts law;

2. Within such States further preference will be given to areas located within soil conservation districts already established and functioning;

3. After July 1, 1939, the prosecution of measures for run-off and water-flow retardation and soil erosion prevention on watersheds in aid of flood control will be undertaken under the Flood Control Acts only in States which have adopted suitable legislation of this type.

It may be useful to describe briefly the procedures which these various State soil conservation districts laws require.[1] Any 25 land occupiers, in the States which have enacted district legislation, have the right to petition a State committee for the establishment of a district. On receiving a petition the State committee holds a public hearing to determine whether a district is needed in the locality and, if so, to define its boundaries. The proposal is then submitted to all of the land occupiers within these boundaries. No district can be established unless the project is approved by at least a majority vote.

Each district is governed by a board of supervisors, all local people. Two are appointed by the State committee and the others are elected.

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[1] A more complete description may be found in the following: United States Soil Conservation Service. soil conservation districts for erosion control. U. S. Dept. Agr., Misc. Pub. 293. 19 pp., illus. 1937.

The districts have the power, among others, to carry out erosion- and flood-control measures, to enter into contracts with farmers, public agencies, and others, to give and receive financial aid, to buy land for retirement from present uses, to make loans and gifts of machinery and seeds, and to develop and recommend land use plans.

Unlike other political subdivisions, the districts do not have the power to tax (except in Colorado).

The district supervisors have, however, authority to formulate ordinances prescribing land use regulations, and, if approved by a referendum of the land occupiers, to enforce them. As a safeguard against ill-considered action the laws all contain provisions for notices, public hearings, referenda, administrative appeal, and judicial review. The procedures are as democratic as it is possible to make them. Not only may no specific regulations be imposed in a district without a favorable referendum vote, but the district itself cannot come into existence until a majority of the land occupiers have registered approval by vote. These laws, in a word, do not authorize any governmental agency to regulate farming, ranching, or lumbering. They simply permit land users themselves to adopt whatever regulations they deem to be in their own interests and in the interest of the general welfare.

STATE ZONING LAWS

Several States have enacted zoning laws. These also are instruments that appear to be useful in forwarding a flood-control program.

Zoning provides a means by which local people may exercise reasonable restrictions over the use of land and structures; it affords a democratic means by which local groups, through local units of government, may regulate the use of private property. After a State has passed the necessary enabling legislation, zoning ordinances may be adopted. Such ordinances may reserve areas for forestry, recreation, and watershed protection or prevent further settlement in areas frequently subjected to serious flood damages. Since the responsibility for the formulation and enforcement of land use regulations under established zoning procedure rests with local people, there need be little fear that unreasonable or unworkable restrictions on the use of land will be imposed.

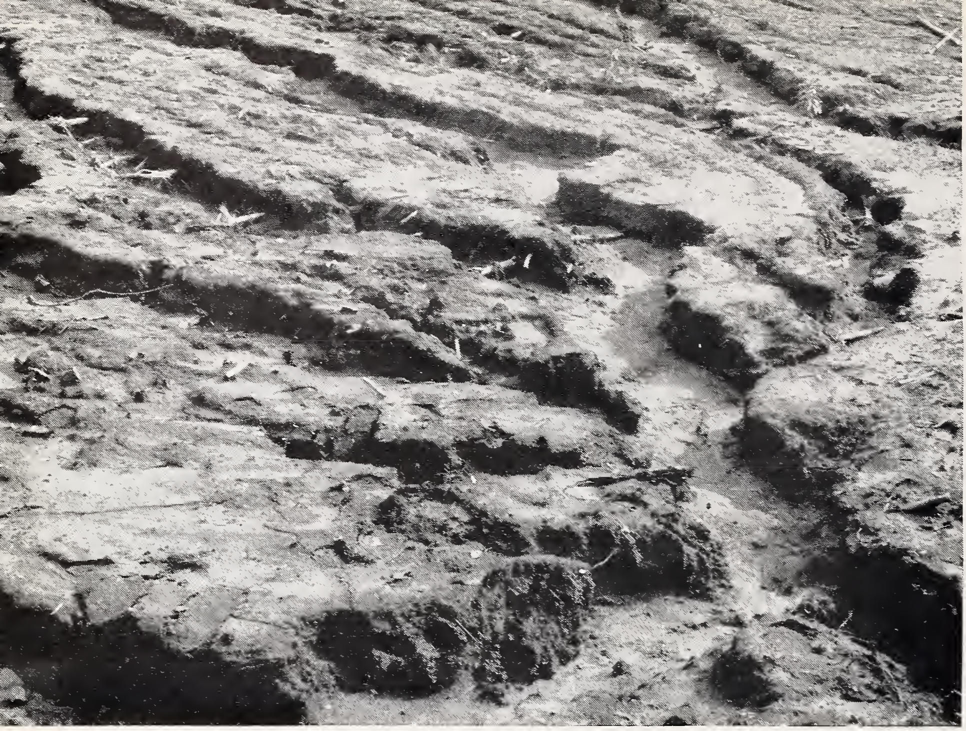
On many watersheds there are extensive areas, often located some distance from the main rivers, which are of little agricultural value and subject to serious erosion. These areas might be restricted against further use for agriculture under rural-zoning laws. If such lands were used for forestry and recreational purposes, and a positive conservation policy were followed, the timber and other vegetative growth on the land would help materially to prevent erosion and rapid run-off. Rural zoning, through the establishment of use districts, is one means of giving effect to such a program.

Plainly, a program for flood control should include the cessation on the flood plains of those land uses, public and private, which result in periodic property losses and risk of life and health. Persons who assume such risks certainly cannot present valid claims against the public treasury when their gambles end in personal losses. Further encroachment on flood-plain areas may be avoided by flood-plain zoning. By restricting the use of land and structures in the immediate path of floodwaters, flood-plain zoning offers a means of preventing or reducing property damages and human suffering.

When our main rivers are in high flood, it is not possible to prevent serious damage to properties along or near the river courses. It is better to get out of the way. In areas certain to be seriously and frequently flooded, prohibition of year-around residence and the erection of certain types of farm buildings would prevent millions of dollars of property losses and a great deal of suffering.

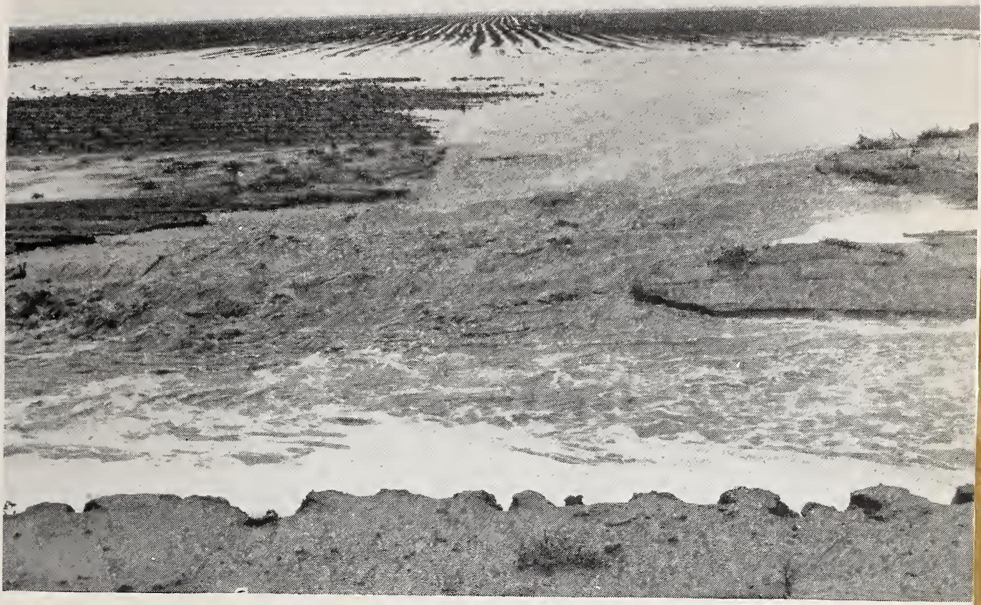
PICTORIAL REVIEW OF WATER CONTROL BY LAND MEASURES

Soil under forest or old sod is mellow, friable, and highly absorbent.



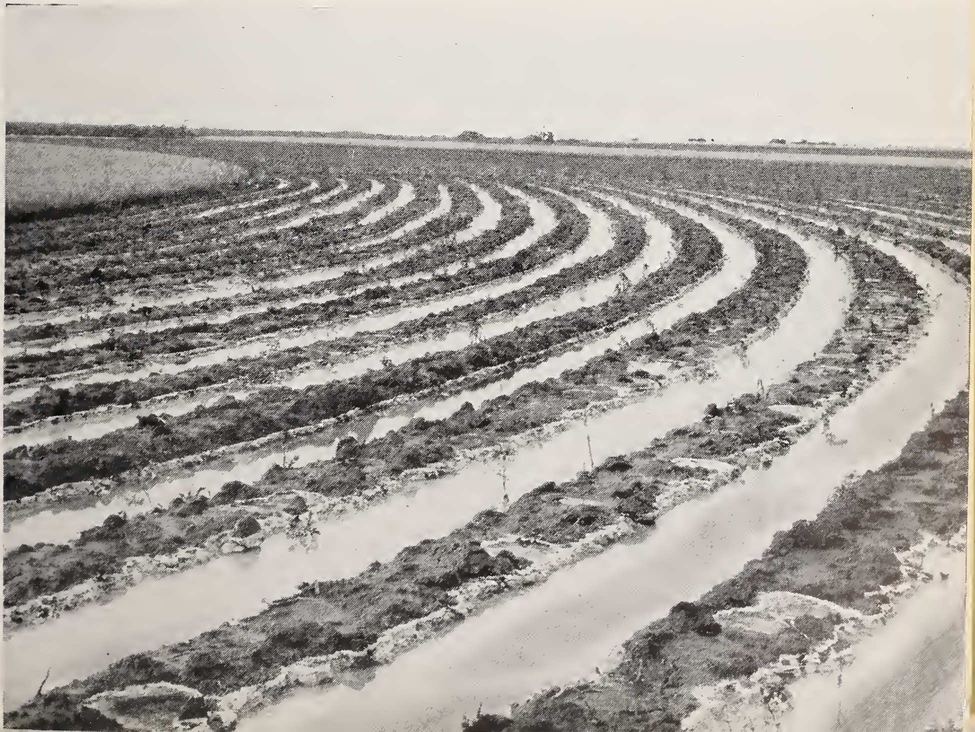
Slopes improperly cultivated lose soil and water quickly.

Little soil and water is lost from slopes protected by thick-growing vegetation.



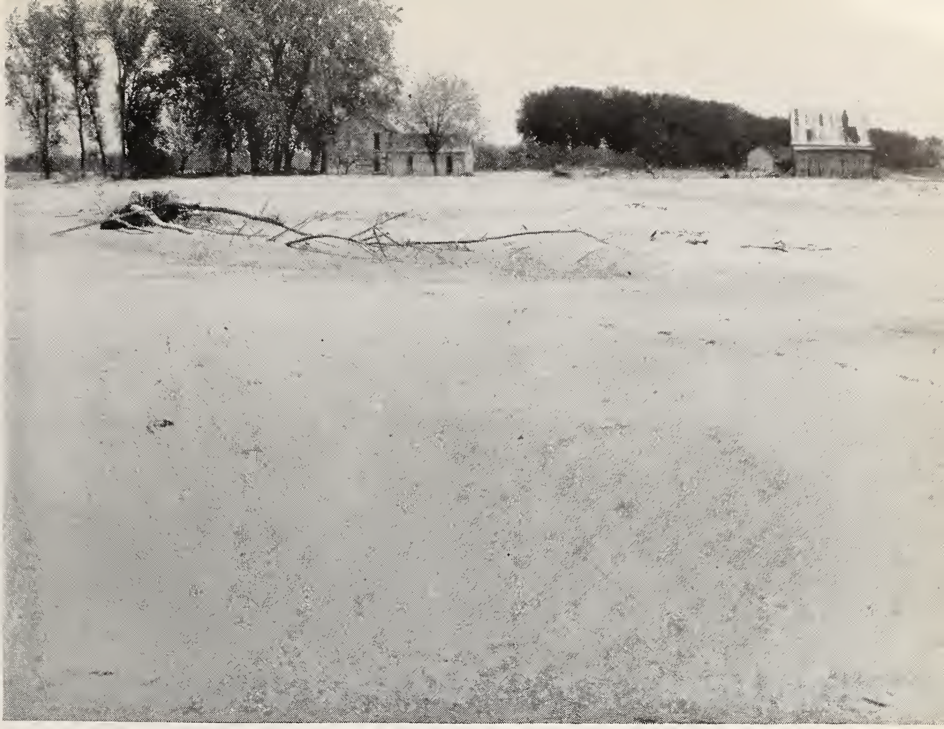
Rows pointing downhill may become channels of destruction.

By cultivating around the hill, each furrow, each harrow scratch, becomes in effect a small dam.



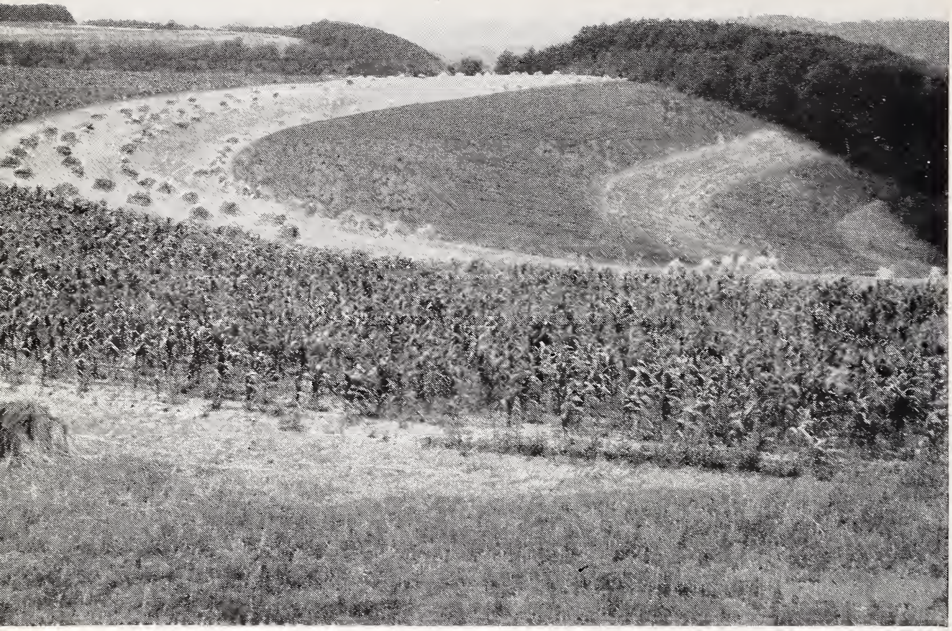
Soil from our farms and pastures shoals the channels of rivers.

Reservoirs fill with the debris of erosion.



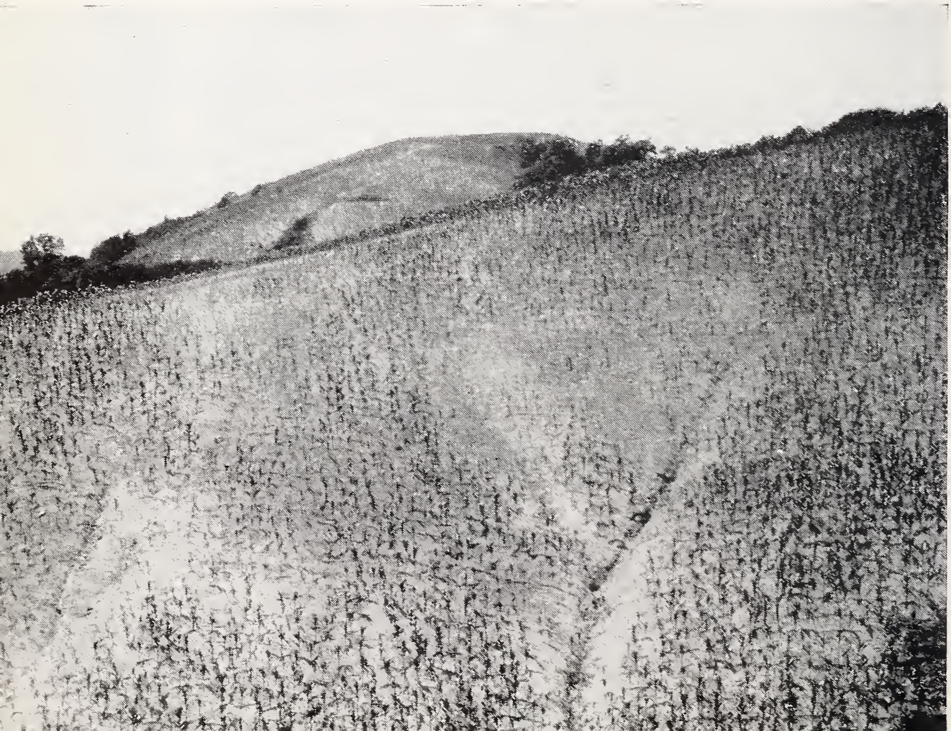
Fertile soils are buried under sterile sand and gravel.

Damages by the many small, local floods may, in the aggregate, exceed damages by the great floods.



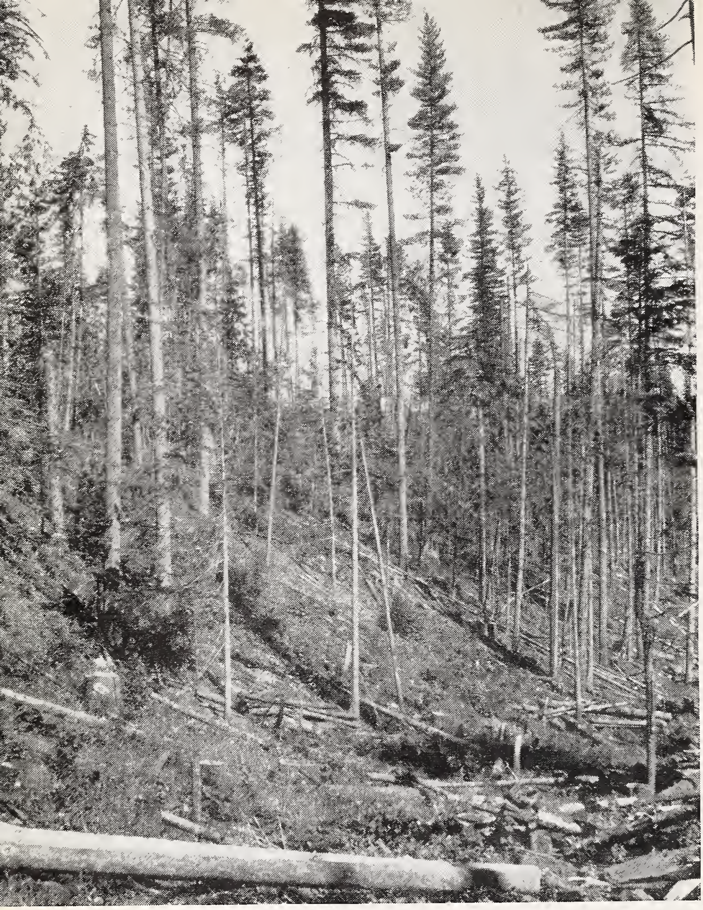
By fitting the crop pattern to the slope of the land, hillsides may be safely farmed.

Cultivated slopes as steep as these are conspicuous sources of silt and floodwater.



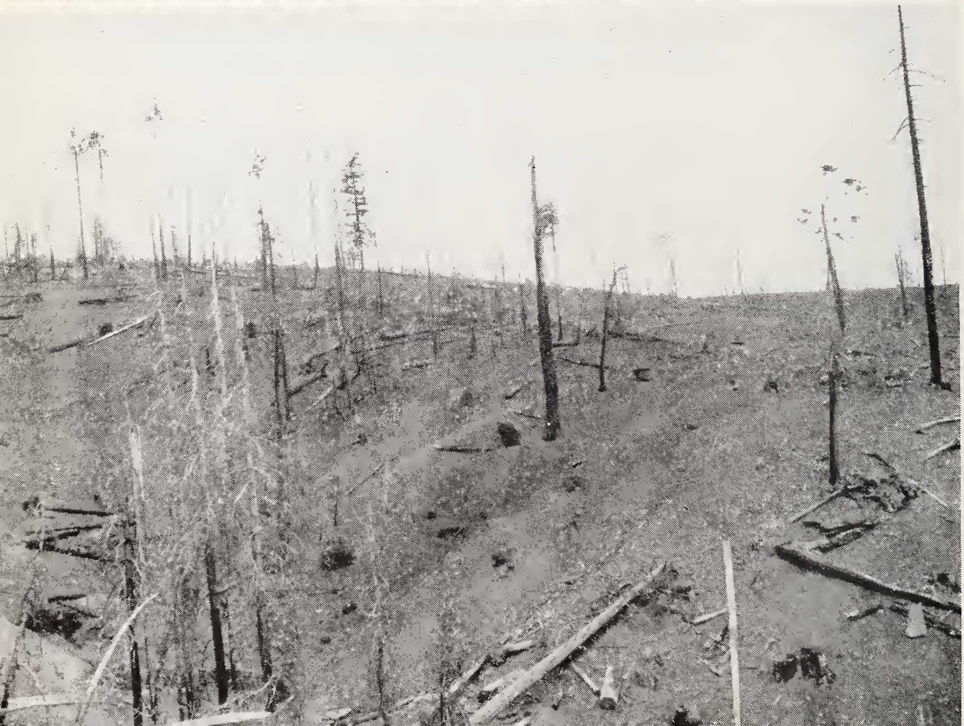
Contours in pastures hold water from the streams.

Terraces on cultivated land prevent quick concentration of water in natural channels.



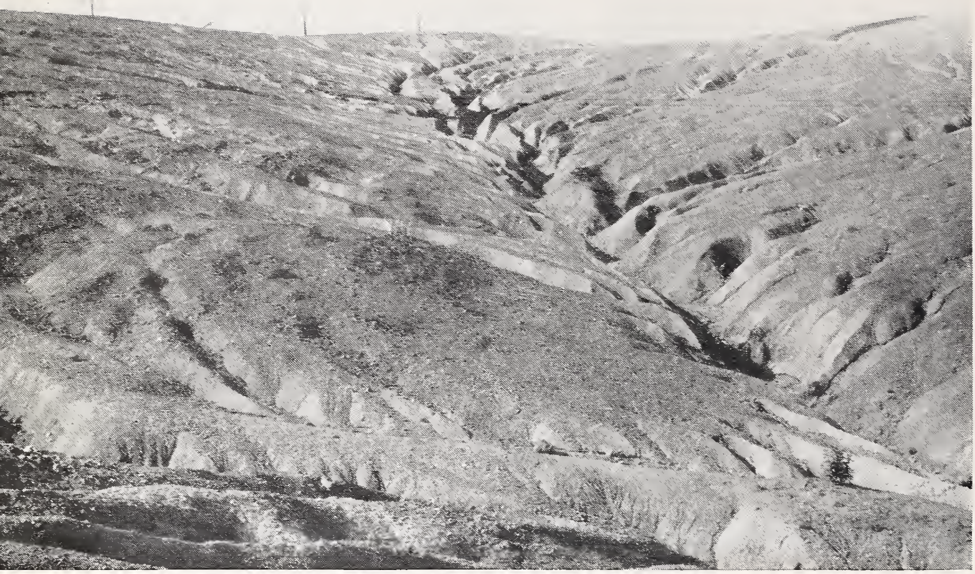
Enough vegetation survives selective logging to provide partial protection.

"Clean" cutting removes practically all natural curbs on waterflow.



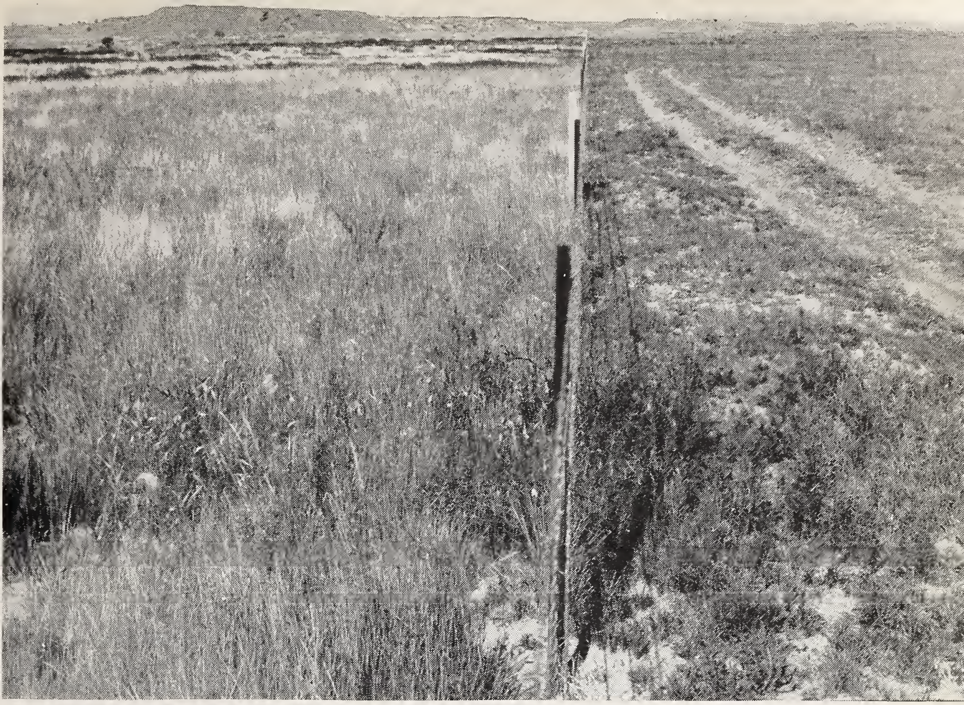
A properly managed farm woods contributes to flood control.

Grazing the farm woods detracts greatly from its water-control values.



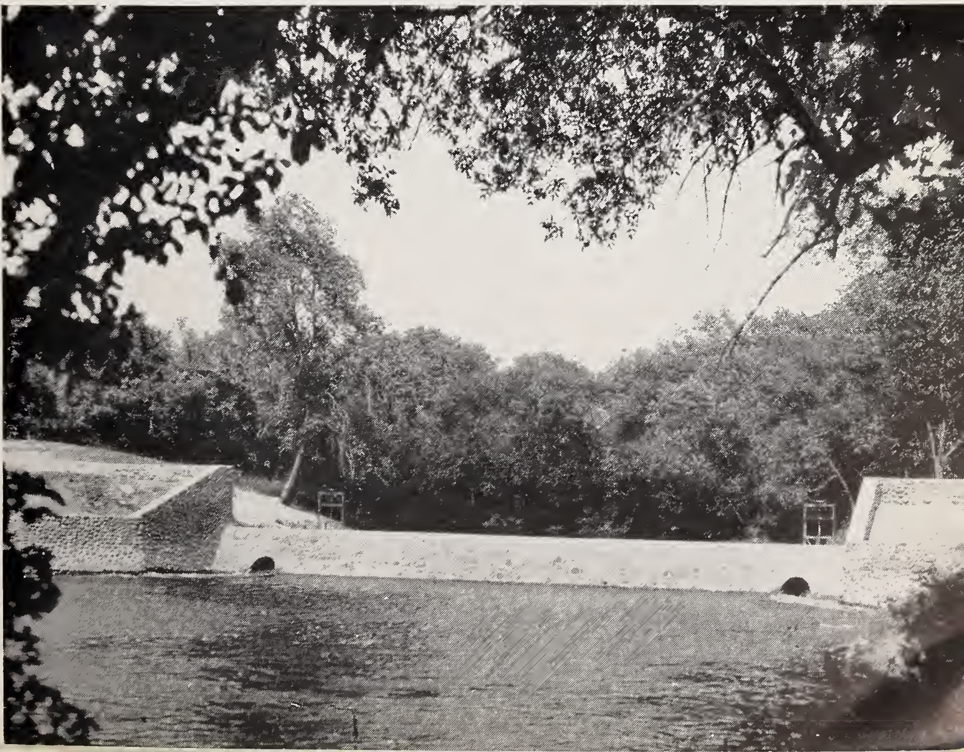
Smelter-denuded areas illustrate the ultimate consequences of loss of vegetation.

Land measures for water control include planting of trees, shrubs, and grasses.



At the left, a range protected; at the right, a range overgrazed.

Small structures on little headwater streams retard waterflow.



APPENDIX: Chronology of Flood-Control Mandates to the Department of Agriculture

Woven into the long history of Congressional mandates to the Department of Agriculture there are a number that deal with flood control. Listed below in chronological order are the laws in force which authorize the Department or certain of its agencies to engage in flood-control work or types of work which may contribute to flood control.

1890: When Congress transferred the weather service to the Department of Agriculture it provided for issuance of flood signals.

1911: The Weeks Forest Purchase Act authorized the Secretary of Agriculture to take certain steps toward "regulating the flow of navigable streams."

1924: The Clarke-McNary Act charged the Department to purchase forest, cut-over, or denuded lands within the watersheds of navigable streams and authorized it to determine the location of public lands "chiefly valuable for stream flow protection."

1928: The Mississippi Flood Control Act authorized the Secretary of Agriculture to study ways in which forestry might aid in control of Mississippi River floods.

The McSweeney-McNary Act authorized investigations to determine methods of preventing erosion and controlling water flow.

1929: Congress provided for field research stations to develop measures to prevent erosion and retard run-off.

1933: Legislation for relief of unemployment authorized work to prevent forest fires, floods, and soil erosion.

1935: Congress established the Soil Conservation Service and declared it to be the policy of Congress to provide permanently for control and prevention of soil erosion and thereby preserve natural resources and control floods.

The Fulmer Act authorized the Secretary of Agriculture to enter into cooperative agreements with the States in a national program for better forest-land management.

1936: The Soil Conservation and Domestic Allotment Act included flood control among its major objectives.

The Flood Control Act of 1936 provided that "Federal investigations and improvements of rivers and other waterways for flood control and allied purposes shall be under the jurisdiction of and shall be prosecuted by the War Department"; that "Federal investigations of watersheds and measures for run-off and waterflow retardation and soil erosion prevention on watersheds shall be under the jurisdiction of and shall be prosecuted by the Department of Agriculture"; designated a long list of localities at which the Secretary of War is "directed to cause preliminary examinations and surveys for flood control," and the Secretary of Agriculture is "directed to cause preliminary examinations and surveys for run-off and waterflow retardation and soil erosion prevention on the watersheds"; and appropriated $10,000,000 to be expended in equal amounts by the Departments of War and Agriculture for carrying out the examinations and surveys provided for in the act.

1937: Congress authorized and directed the Secretary of Agriculture "to cause a preliminary examination and survey to be made for run-off and waterflow retardation and soil erosion prevention" of the Santa Maria watershed in California with a view to the control of its floods.

The Bankhead-Jones Farm Tenant Act authorized and directed the Secretary of Agriculture "to develop a program of land conservation and land utilization, including the retirement of lands which are submarginal or not primarily suitable for cultivation, in order thereby to correct maladjustments in land use, and thus assist in controlling soil erosion, reforestation, preserving material resources, mitigating floods, preventing impairment of dams and reservoirs, conserving surface and subsurface moisture, protecting the watersheds of navigable streams, and protecting the public lands, health, safety, and welfare."

Congress passed an act providing for preliminary examinations and surveys for run-off and water-flow retardation and soil-erosion prevention on the watersheds of the Rio Grande and the Pecos River and their tributaries above the point of their confluence.

The Water Facilities Act recognized "that the wastage and inadequate utilization of water resources on farm, grazing, and forest lands in arid and semi-arid areas of the United States resulting from inadequate facilities for water storage contribute to the destruction of natural resources, injuries to public health and public lands, droughts, periodic floods," etc., and declared it to be the policy of Congress to assist in providing water facilities in such areas.

An amendment to the Flood Control Act of 1936 authorized the Secretary of Agriculture to make preliminary examinations and surveys for run-off and water-flow retardation and soil-erosion prevention on the watersheds of those waterways which the Secretary of War had heretofore been authorized and directed to examine and survey with a view to the control of their floods.

1938: Congress authorized the Secretary of Agriculture to acquire by purchase lands within the exterior boundaries of the Cache National Forest in Utah that they may be managed with other lands of the United States so as to minimize soil erosion and flood damage.

An appropriation act to the War Department for civil functions transferred $7,000,000 to the Secretary of Agriculture and provided that "of such sum not to exceed $3,000,000 shall be available for preliminary examinations and surveys, as authorized by law, for run-off and water-flow retardation and soil-erosion on the watersheds of flood-control projects, and not to exceed $4,000,000 shall be available for the prosecution, under plans to be approved by the Secretary of Agriculture, of works of improvement for measures of run-off and water-flow retardation and soil-erosion prevention upon the watersheds of waterways for which works of improvements for the benefit of navigation and the control of destructive floodwaters and other provisions have been or hereafter may be adopted or authorized by law, * * *."

Congress authorized the Secretary of Agriculture to acquire by purchase lands within the exterior boundaries of the San Bernardino and Cleveland National Forests in Riverside County, Calif., that they may be managed with other lands of the United States so as to minimize soil erosion and flood damage.

Appropriations for the Department of Agriculture for the fiscal year ending June 30, 1939, provided funds to the Weather Bureau for "gaging and measuring of the flow of rivers and the issuing of river forecasts and warnings"; to the Forest Service "to protect, administer, and improve the national forests, including tree planting and other measures to prevent erosion, drift, surface wash, soil waste, and the formation of floods. * * * For acquisition of land in accordance with the provisions of the Act entitled 'An Act to facilitate the control of soil erosion and/or flood damage originating upon lands within the exterior boundaries of the Uinta and Wasatch National Forests, Utah' ";

and to the Soil Conservation Service "for carrying out preventive measures to conserve soil and moisture, including such special measures as may be necessary to prevent floods and the siltation of reservoirs."

Congress authorized the Secretary of Agriculture to acquire by purchase lands within the exterior boundaries of the Nevada and Toiyabe National Forests in Nevada in order that they may be so managed with other lands of the United States as to minimize soil erosion and flood damage.

The Flood Control Act of 1938 authorized and directed the Secretary of Agriculture to make preliminary examinations and surveys for run-off and water-flow retardation and soil-erosion prevention on designated watersheds; in order to effectuate the policy declared in the Flood Control Act of 1936, directed the Department of Agriculture to prosecute flood-control measures on lands in the watersheds of certain rivers in correlation with the flood-control program of the Department of War; authorized the sum of $10,000,000 to be appropriated for expenditure at the rate of $2,000,000 a year during the 5-year period ending June 30, 1944; authorized the Secretary of War to allot to the Weather Bureau funds to establish, operate, and maintain current information service on precipitation, flood forecasts, and flood warnings—expenditures not to exceed $375,000 a year; authorized $10,000,000 for expenditures in equal amounts by the Departments of War and Agriculture for carrying out the examinations and surveys to be prosecuted by said Departments in the period ending June 30, 1944.

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